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Exponential Consensus of Discrete-time Non-linear Multi-agent Systems via Relative State-dependent Impulsive Protocols

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Abstract

In this paper, we discuss the exponential consensus problem of discrete-time multi-agent systems with non-linear dynamics via relative state-dependent impulsive protocols. Impulsive protocols of which the impulsive instants are depended on the weighted relative states of any two agents are introduced for general discrete-time multi-agent systems. The analysis of such impulsive protocols are transformed into an investigation on reduced fixed-time impulsive protocols by constructing a map, which is achieved mainly by a derived B-equivalence method in discrete-time domain. Our main results indicate that the exponential consensus of the multi-agent systems via relative state-dependent impulsive protocols can be achieved if the reduced systems via fixed-time impulsive protocols can achieve exponential consensus, which need to satisfy suitable sufficient conditions. Numerical simulations are presented to support the theoretical results.

Keywords: Relative state-dependent impulsive protocols, Discrete-time non-linear multi-agent systems, Exponential consensus

1. Introduction

It is worth noting that multi-agent systems have drawn much attention due to the promising application. Many single agents which can represent different individuals with their own state and dynamics constitute a group as so-called multi-agent system. Multi-agent systems are tools to achieve goals that must be done by cooperation including formation, flocking, rendezvous and so on (Tanner, Jadbabaie, & Pappas, 2007; Zhou, Lu, & Lu, 2006; Lu, & Chen, 2005). The consensus problem, as a fundamental problem demanding the states finally to be same has been naturally introduced and has kept attracting researchers in last two decades.

In a multi-agent system, each agent shares information with its neighbors to reach an agreement. Once the agreement is reached by every agent, the whole system achieves consensus. Existing researches mainly focused on the consensus problem (Jadbabaie, Lin, & Morse, 2003; Lu, Lu, Chen, & Lu, 2013; Chen, Lu, & Yu, 2011) based on integrator and first-order dynamics. Recently the consensus problem of second-order multi-agent systems (Ren, 2007; Mei, Ren, & Chen, 2016; Sun, Austin, Lu, & Chen, 2011) with states which represent both position and velocity became more attractive, where distributed consensus problem was considered with both undirected and directed networks topologies. And because non-linear phenomena are everywhere in real-world, many studies (Rezaee, & Abdollahi, 2017; Li, Chen, Dong, & Xia, 2016; Fan, Chen, & Zhang, 2014; Li, 2016) were done with the non-linear dynamics of multi-agent systems. Hua, You and Guan (2017) studied the adaptive leader-following consensus of second-order multi-agent systems with time-varying non-linear dynamics by a fully distributed algorithm. And the consensus problem that is mainly concerned with the analysis of the second-order locally dynamical consensus of multi-agent systems with arbitrarily fast switching topologies was studied in Li, Liao, and Huang (2013). Shen and Shi (2016) studied the output consensus control problem of uncertain second-order nonlinear multi-agent systems with unknown non-linear dead zone. In Wen et al.(2017), the consensus tracking problem was investigated by an observer-based protocol, which indicates that only the relative output measurements of neighboring agents are available for information exchange. However, in some specific circumstances, discrete-time dynamics are more suitable for analyzing real problems. There are also many researches (Han, & Li, 2018; Gao, Yu, Shao, & Yu, 2016; Liang, Zhang, Wang, & Wang, 2015) on the consensus problem of discrete-time multi-agent systems with linear or non-linear dynamics.

Moreover, impulsive control systems were paid more attention in recent years in that an evolution of a system may suddenly changes in real circumstances. To get closed to the reality, impulsive control method was introduced because its high efficiency to multi-agent systems with high-robustness and low-cost. Impulsive control had been widely applied to the synchronization and consensus problems (Lu, Ho, & Cao, 2010; Liu, Lu, & Chen, 2013; Morarescu, Martin, Girard, & Muller-Gueudin, 2016) with kinds of complex networks over

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